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Wildlife Conservation in Zambia: Impacts on Rural Household Welfare

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Summary. — We investigate the impact of wildlife conservation policies in Zambia on household welfare in game management areas (GMAs), which are buffer zones around national parks. Analysis of data from a nationwide survey of rural households shows that GMAs are positively associated with household income and crop damage from wildlife conflicts. Gains and damages were greatest among households in GMAs with greater wildlife diversity, with net gains relatively greater for wealthier households. Households in prime (well stocked) GMAs were more likely to participate in off-farm wage and self-employment compared to other rural households, but they were also more likely to suffer crop losses related to wildlife conflicts. The findings suggest that wildlife conservation and tourism development can contribute to pro-poor development, but may be sustainable only if human–wildlife conflicts are minimized or compensated.

Key words — wildlife conservation, national parks, rural development, Africa, Zambia

1. INTRODUCTION

Rural poverty in Zambia remains a persistent problem. The majority of rural households rely on subsistence agriculture as their main livelihood, which is typically insufficient to ensure food security. Although most households seek livelihood diversification opportunities as part of their strategy for risk management and income generation, such opportunities are often out of reach for the poorer households, due to capital or labor constraints as well as a general scarcity of off-farm employment. Providing access to off-farm employment in rural areas is one of the Zambian Government's key objectives for national development. Acknowledging the need to strengthen linkages within the economy and focus on sectors that generate broad-based wealth and job creation, the Government of Zambia plans to promote sectors thought to be pro-poor and labor intensive. Tourism has been identified as a priority sector for pro-poor growth (Government of Zambia, 2006, 2011) in large measure due to its potential to generate off-farm income opportunities in rural areas (typically surrounding national parks) where commercial agriculture is a less attractive option.

Tourism is one of the most rapidly growing economic sectors in the world, especially in developing countries; growth rates in international tourist arrivals and receipts in these countries are roughly double the world average (UNWTO, 2006). The share in international tourist arrivals received by developing economies has steadily increased, from 31% in 1990 to 47% in 2010 (UNWTO, 2011). In Zambia, the tourism sector has been growing rapidly in recent years; average annual growth in tourism arrivals between 1990 and 2005 has outpaced the growth rate for developing countries in the period.

Tourism in Zambia is largely based on the country's stock of natural resources, particularly the system of national parks (NPs) and game management areas (GMAs). GMAs serve as buffer zones around NPs and licensed safari hunting is permitted within GMAs. Households in GMAs co-exist with wildlife and primarily practice semi-subsistence agriculture for their livelihoods, but they are often constrained by limited infrastructure, agricultural inputs, and access to credit. The Zambia Wildlife Authority (ZAWA) partners with community organizations to share wildlife management responsibilities and revenue from hunting licenses. Households in GMAs benefit from these arrangements through access to infrastructure development, employment and business opportunities, and revenue sharing; however, they may also suffer negative effects, including crop destruction from increasing wildlife populations and pressure from in-migration on land and other natural

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resources. In interviews with community leaders and residents of villages in GMAs, the human–elephant conflict was cited as the greatest development challenge among GMA households.

In consideration of the policy objectives of promoting wildlife conservation and alleviating rural poverty, it is important to estimate the effects of GMAs on rural welfare as part of an evaluation of the socioeconomic effects of wildlife management policies. Knowledge about the effectiveness of such policies is fundamental for identifying strategies for increasing the contribution of nature-based tourism to poverty reduction. In this study, household survey data were used to measure the effect of GMAs on rural household income. We tested for the effect of GMAs on household income and examined the avenues through which the GMA effect is generated. We also tested for the effect of GMAs on economic losses from crop damages related to wildlife disturbances. We find that households in GMAs enjoy higher levels of income overall, particularly through wage earnings and self-employment, but the gains accrue mostly to wealthier households. Furthermore, households located in prime GMAs (with higher levels of biological diversity) accrue greater benefits, but are also more likely to suffer damage from crop losses related to wildlife. The findings suggest that tourism and wildlife conservation are positively associated with household welfare, but have implications for natural resource management policies and the objectives of pro-poor tourism development, which may be sustainable only if the benefits are distributed more equitably and if human–wildlife conflicts are minimized or compensated.

2. BACKGROUND

During the first decade of independence (1964–74), Zambia was one of the wealthiest countries in sub-Saharan Africa, mainly due to the success of the mining industry, which benefitted from high international prices. However, weaker copper prices and the oil crisis of the mid-1970s led to declines in national income, a greater dependence on foreign borrowing, and deterioration in the balance of payments. Economic growth returned in the late 1990s, fueled by favorable global economic conditions, the impact of economic reforms, expansion of the mining industry, and growth of the construction sector through private investments (Government of Zambia, 2006).

Despite the acceleration of economic growth in the late 1990s, Zambia still suffers from persistent income poverty. In particular, rural poverty in Zambia ranks among the highest in sub-Saharan Africa. According to the 2006 Living Conditions Monitoring Survey (LCMS), 80% of the population in rural Zambia is poor and 67% is extremely poor (Central Statistical Office, 2006). Still, total rural poverty rates have shown a slight decline over the last decade, diminishing from 92% to 80% from during 1993–2006 (see Figure 1) (Central Statistical Office, 2006). In rural areas, the decline in poverty levels can be partly explained by the increased supply of food crops such as cassava, sweet potatoes and groundnuts, as well as export commodities like cotton and tobacco, which have helped to boost rural incomes (Fynn & Haggblade, 2006; Tschirley & Kabwe, 2007).

Since poverty is more acute in rural Zambia, agriculture is one of the main areas of attention for national development, through the promotion of large-scale commercial farms, technological development, and strengthening of upstream linkages. In addition to agriculture, the Government envisions the expansion of a diversified export base and a stronger tourism sector as engines of pro-poor growth (Government of Zambia, 2006).

Tourism is increasingly important for economic growth worldwide, particularly in developing countries. Global tourism revenues grew at an average rate of 11.2% per year during 1950–2010; international tourism arrivals grew at an average annual rate of 10.1%, increasing from 25 million to 940 million visitors (UNWTO, 2011). The sector has become one of the major businesses in international commerce, and represents one of the main sources of economic growth and foreign exchange earnings for many developing countries. The increasing importance of the sector in development is reflected by the growth rate of tourism in low-mid income countries and least developed countries (LDCs), which is roughly double the worldwide growth rate and nearly triple the growth rate in higher income countries (see Figure 2) (UNWTO, 2006).

In Zambia, the tourism sector has been steadily growing over the past years both in terms of arrivals and tourism receipts, and average annual tourism growth has outpaced the growth rate for LDCs. International arrivals have grown at an average rate of approximately 12% since during 1990–2010, and the average annual growth in receipts has been approximately 13% (UNWTO, 2011). The travel and tourism sector is expected to contribute approximately two trillion

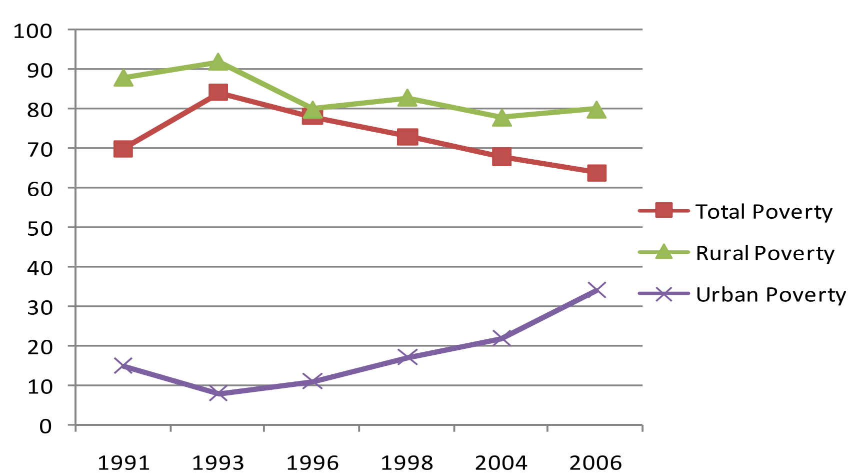

Figure 1. *Poverty incidence in Zambia (%), 1991–2006. Source: Elaborated from CSO data (2008). CSO uses the food energy intake approach to define the poverty line. The caloric requirement per adult equivalent per day is set at 2,721 calories.*

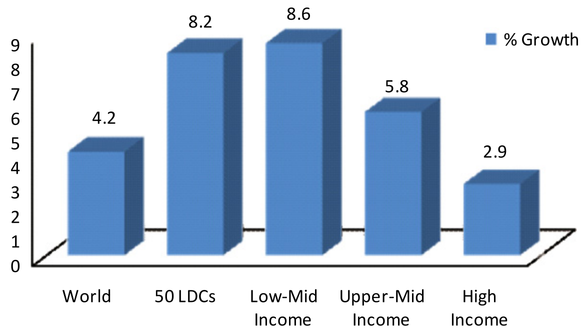

Figure 2. *Average annual tourism growth, by income classification of countries (1990–2005). Source: U.N. World Tourism Organization.*

Kwacha in 2011 (equivalent to about US$400 million), or about 2.3% of total gross domestic product (GDP), and when combined with the indirect (inter-industry) effects, the travel and tourism economy in Zambia supports approximately 6.8% of GDP (WTTC, 2011).

Tourism in Zambia relies largely on the country's endowment of natural resources, including the system of protected areas, which consists of 19 NPs and 35 GMAs that cover 30% of the total territory. Figure 3 presents a map depicting the system of protected areas in the country. NPs are designated for the protection of wildlife, ecosystems and biodiversity. There are no human settlements, and only photographic safaris and wildlife viewing (i.e., nonconsumptive uses) are permitted. GMAs are designated as buffer zones around NPs, and human settlements are contained within their boundaries. They were intended to promote sustainable safari hunting as an alternative to other economic activities not compatible with wildlife protection.

GMAs are classified as prime, secondary, specialized, or under-stocked. Prime areas are those in which trophy species are abundant and can sustain safari hunting. Secondary GMAs are those in which species are less abundant but that can still sustain limited hunting. Specialized GMAs are frequently found in wetland areas and are characterized by the presence of only a few species (usually antelope). In under-stocked GMAs, wildlife populations are sparse and hunting quotas are limited.

During the last two decades, the Government of Zambia has been implementing co-management agreements for the management of wildlife use (consumptive and nonconsumptive) with communities in GMAs. Such administrative arrangements were developed in response to local resistance to parks and protected areas, and are frequently viewed as more effective alternatives to natural resource management than those that depend upon centralized control (Bandyopadhyay & Tembo, 2010). The Zambia Wildlife Authority (ZAWA) promotes the organization of Community Resource Boards (CRB) to become partners in both wildlife protection and the sharing of license revenues from hunting and photographic safaris. This approach, known as Community Based Natural Resource Management (CBNRM), has the dual goal of enhancing the welfare of local communities and creating incentives for the protection and conservation of natural resources (Leach, Mearns, & Scoones, 1999).

Although community participation has been described as integral to effective and sustainable pro-poor tourism development, the evidence of community-based approaches as potential avenues of poverty reduction through revenue sharing and community participation in management has been mixed. Wildlife management schemes in Zambia have been successful at protecting large mammals through enforcement rather than the distribution of socioeconomic benefits (Gibson & Marks, 1995). The benefits of participation in community-level institutions were found to be distributed unevenly among households in GMAs and between national park systems in Zambia (Bandyopadhyay & Tembo, 2010). Other CBNRM programs such as CAMPFIRE (Communal Areas Management Program for Indigenous Resources) in Zimbabwe have been promoted as having contributed to the dual objectives of conservation and rural development, but also criticized as having failed at effectively controlling poaching and empowering local communities (Rodary, 2009). Community-based tourism

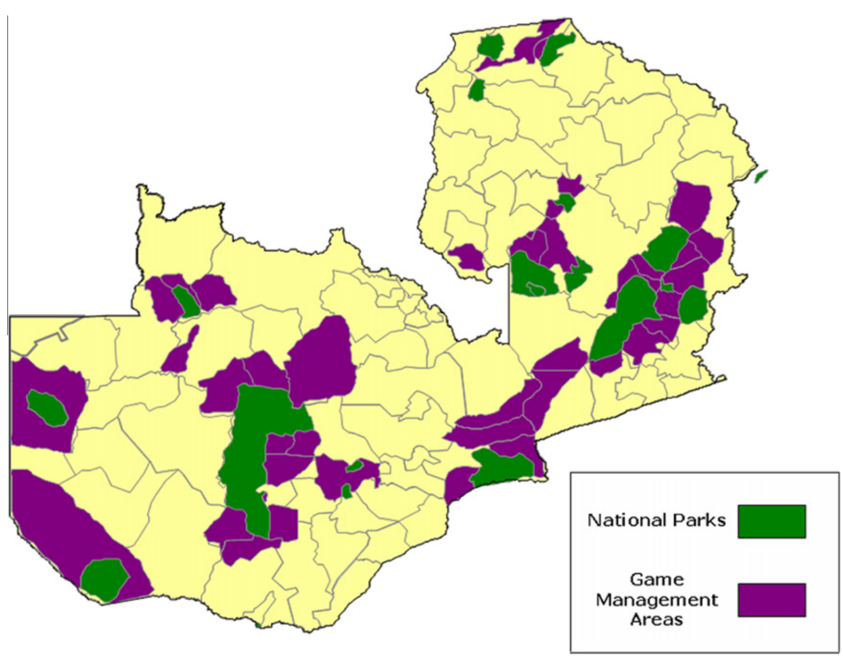

Figure 3. *Protected area system in Zambia. Source: Zambia Wildlife Authority.*

enterprises in Kenya have been described as relying heavily on donor funding and not having a significant impact on poverty reduction at the household level (Manyara & Jones, 2007). Critics of community-based conservation schemes have highlighted the heterogeneity of communities and the frequent misperceptions of rural household incentives in program design (Agrawal & Gibson, 1999; Gibson & Marks, 1995). Some have called for greater decentralization of authority to local groups and for greater emphasis on institutional arrangements that more fully reflect social-ecological interactions (Berkes, 2004).

The co-management of wildlife resources presents opportunities and threats for communities living in GMAs. Through the CBNRM program, communities receive a share of the revenues generated from hunting licenses and concession fees paid by hunting outfitters. These funds are distributed to Village Action Groups (VAGs), which use the revenue to employ village scouts (who aid in wildlife protection) and for implementation of community development projects (such as the construction of health clinics, schools, water wells, and boreholes). Tourism development also creates opportunities for wage employment and entrepreneurship, in addition to the benefits from increased access to infrastructure and services. However, the realization of these opportunities depends on various factors, such as the potential of the tourism industry to create employment and revenues through hunting licenses, the appropriate planning of land uses and human settlements, the transparency with which the main actors (ZAWA, area chiefs, community representatives) manage the program, the actual degree of devolution of decision making to communities, and the community's commitment to protect wildlife.

The effectiveness of the program is threatened by unintended negative effects, such as crop destruction with increasing wildlife populations and the pressures of in-migration on land and other natural resources. Human–wildlife conflict represents one of the biggest challenges for communities living in GMAs or near national parks. Farmers are routinely affected by crop destruction, mainly by elephants, which have proven to be extremely difficult to control. Despite efforts from NGOs and ZAWA to help communities with electric fences and other strategies (e.g., chili fences, beating of drums) to keep elephants away from crops, the problem remains serious in areas where significant elephant populations are found. The efforts of ZAWA, safari outfitters, and village scouts to control poaching in GMAs—in an effort to increase tourism related incomes—may exacerbate the problem for households whose main economic activity is farming. The problem of crop losses from wildlife was cited by village leaders and residents as the greatest impediment to socioeconomic development in GMAs. Despite a reported increase in crop losses and injuries related to wildlife conflicts, there is currently no means for compensating households that suffer such losses. Incentives to compensate farmers for wildlife damages are popular among public and private agencies and donors to promote conservation in many parts of the world; however, such schemes have met with mixed success, often because of insufficient funds, high transaction costs, fraud, corruption, and moral hazard problems. Compensation induces entry of victims, which thereby generates excessive damages (Baumol & Oates, 1988). Furthermore, in an open economy, compensation depresses wildlife stocks and also reduces welfare, which calls for attention to local conditions in considering the desirability of implementing a wildlife damage compensation scheme (Rondeau & Bulte, 2007).

Effectiveness of the operation of the program depends upon the transparent and efficient administration of revenues generated through hunting licenses and concessions. Revenues are collected by ZAWA and distributed to the CRBs. The CRBs are mandated to allocate 45% of the revenues received from ZAWA to resource protection (employment of village scouts and funding of other logistic operations), 35% to the implementation of community development projects and 20% to administration costs (Roe et al., 2009). Bwalya (2003) described the shortcomings of the process and noted a lack of transparency and accountability regarding the management of funds, and poor information sharing on community entitlements. Similar views were supported by interviews with village leaders and residents who also complained about insufficient funds, delayed payments and no access to financial records.

Given the numerous potential influences of GMA policies on rural welfare, the observable impact of GMA policies on household welfare will be the net effect of the potential benefits and costs associated with wildlife management policies. It is possible, for example, that the benefits from hunting revenues and employment in tourism could be outweighed by crop losses and the opportunity cost of alternative uses of the land. We focused on the effect of GMAs on total household income, sources of income, and crop losses from wildlife damage.

3. THEORETICAL FRAMEWORK AND MODEL SPECIFICATION

We estimated the impact of living in a GMA on household welfare and test the null hypothesis that GMAs have no effect on income. To estimate the GMA effect, all other factors that affect household income were held constant. Typically, the determinants of household income include human capital, physical assets, locational characteristics, and other social and institutional assets (DeJanvry & Sadoulet, 2001). The relationship can be represented as:

$$Y = f(HC, PC, SA, LC) \quad (1)$$

where Y is the level of household income, HC is a vector of human capital and socio-demographic variables, PC is a vector of physical capital variables, SA is a vector of social and institutional asset variables, and LC is a vector of locational variables. To test the effect of living in a GMA on household income, we created a locational dummy variable representing households that live in a GMA.

We use data from the Impact of Game Management Areas on Household Welfare survey, which was jointly commissioned by the Natural Resources Consultative Forum, the World Bank, and ZAWA as part of an effort to inform policy on the effectiveness of the GMA arrangements administered by the government, private sector, and the respective communities. The specific objective of the survey was to determine the impact of GMAs on the economic welfare of households residing in them. The survey covered areas adjacent to four national park systems: Bangweulu (including Isangano, Lavushi and Kasanka NPs), Kafue (including Kafue, Blue Lagoon and Lochinvar NPs), Lower Zambezi (Lower Zambezi NP), and Luangwa (including North and South Luangwa NP). Each of the park systems was considered a reporting domain in the sampling process.

Stratified two-stage cluster sampling was used to identify households in 139 standard enumeration areas (SEAs) adjacent to four national park systems. In the first stage, the list of SEAs within GMAs was obtained by overlapping overlaying GMA digital maps from ZAWA with maps of SEAs from the Central Statistical Office (CSO). All SEAs outside GMAs but bordering national parks were included as control areas. A sample of 139 SEAs was drawn from the two lists using

probability proportional to size (PPS), and drawing upon the 2000 census of population and housing.

In the second stage, all households in each SEA were listed, and sample households were selected for interviewing using a probability-sampling scheme. The total number of households interviewed was 2,769 out of a target of 2,800, amounting to a 99% response rate. Approximately half of the respondents reside in GMAs (58%) and the other half in nonGMA or control areas (42%). Data were collected at the household and community levels using household and community questionnaires, respectively. Key informants were interviewed including the village leaders, chairpersons of CRBs and VAGs, school headmasters, and others.

In this study, household welfare was measured by total income. All welfare indicators have advantages and disadvantages. Barrett, Reardon, and Webb (2001) advocate for the use of multiple welfare indicators to cross check on inference. Although income may be subject to under-reporting and sometimes difficult to measure, as a welfare indicator it allows for comparison with other measures such as consumption expenditures and household capital, and it permits the analysis of the avenues through which it is earned, such as farming or formal employment. Household income in rural areas comes from many sources. An income variable was computed to capture the total value of household income, including farm income (total value of sold and retained harvest, value of livestock sold, consumed and owned, value of forest products, value of sales from honey, income from hiring of equipment and income from game meat) and off-farm income (from wage employment and self employment). The household income variable is continuous with a small number of zero observations reported (presumably corresponding to missing or incorrectly recorded data). Missing observations represented only 1.9% of the total sample, so they were dropped for the purposes of the analysis. Eliminating the zero values makes the income variable positive for all observations and allows for the use of Ordinary Least Square (OLS) estimation.

The potential for sample selection bias (related to migration to or from GMAs) gives rise to the question of endogeneity, which creates bias and inconsistency in the OLS parameters. Households migrating into GMAs may be attracted by employment opportunities or existing amenities derived from the investment in community projects. Households emigrating from GMAs (perhaps those most oriented toward agriculture) might do so as a consequence of human–wildlife conflicts. Overall, only 11.6% of households surveyed migrated in the past 5 years; 12.8% of households migrated into GMAs, and 9.9% moved into other rural areas (not designated as GMAs). To examine the effect of migration in endogeneity, we tested for structural differences in the two sub-samples using a test of equality between subsets of coefficients (Chow, 1960). The null hypothesis is that the parameters for households that migrated are equal to those for households that did not migrate. The F-statistic for testing the restriction that the coefficients in the two subsets are the same is 1.99. The critical value is 2.46 at 1% significance, so the null hypothesis cannot be rejected. We conclude that households that migrated are statistically identical to those that did not migrate.

Since the assignment of households to the treatment (GMA) and control (nonGMA) groups is not random, the estimation of the effect of GMAs on household income may be biased by confounding factors, such as characteristics that affect both participation and outcome. We used propensity score matching (PSM) to test for bias in the estimation of treatment effects. PSM allows for the estimation of unbiased treatment effects by controlling for these confounding factors, based on the idea that the bias is reduced when the comparison of outcomes is performed using treated and control households that are similar. Treatment was modeled through a probit framework with the aim to estimate the conditional probabilities of participation (given the observed characteristics), also known as the propensity scores (PS). PSM involves finding, for each treatment unit, matches in the control group based on observable characteristics. The final specification of the covariates included in X was based upon the variables' relative effects on the variance and bias of the estimates. The inclusion of variables that are unrelated to the treatment but related to the outcome will decrease the variance of an estimated treatment effect without increasing bias (Brookhart et al., 2006). Consequently, we included in X all covariates that are significantly correlated with the outcome variable, whether or not they are correlated with the treatment variable. However, we excluded all covariates that are themselves affected by the GMA status, such as income (Brookhart et al., 2006; Maertens & Swinnen, 2009). Thus, the average effect of treatment on the treated was computed as the weighted average of the difference in the outcome variable between treatment households and matched control ones. We matched using kernel functions and perform inferences using bootstrapped standard errors.

The balancing effects of the PS were tested using a number of procedures, including t tests for the differences in covariate means between the two groups (GMA and nonGMA households) before and after matching, effectiveness in reducing standardized bias to within acceptable levels (not substantially larger than 5%), and ability to drive the overall probit relationship to insignificance as measured by a joint likelihood ratio test and pseudo R^2 (Caliendo & Kopeinig, 2008; Rosenbaum & Rubin, 1983). The results show that all these balancing requirements were satisfied using our specification of the PS model. The estimated propensity scores also satisfied the common support requirement, with the region of common support being within 0.35–0.85 of the propensity score distribution. The PSM results show that the average treatment effect of the GMA on household income is 0.147.

(a) *GMA effect on household income*

We used ordinary least squares (OLS) regression to estimate the effect of GMAs on household income. The basic OLS estimation for the determinants of income takes the form:

$$\ln Y_i = \alpha + \beta_1 HC + \beta_2 PC + \beta_3 SA + \beta_4 LC + \mu_i \quad (2)$$

where i represents an individual household in the sample, $\ln Y_i$ is the natural logarithm of income for each household. The selection of variables included in the model is guided by a review of literature on the determinants of rural household income (Barrett et al., 2001; DeJanvry & Sadoulet, 2001; Reardon, 1997; Yúnez-Naude & Taylor, 2001), factors specific to Zambia that influence how these variables are specified, and data availability. See Table 1 for variable names, definitions, and statistical properties.

Human capital and socio-demographic variables include household characteristics such as the age and sex of the household head, the level of education of the highest educated household member, and the household size. Physical capital variables include total area cropped in hectares (a proxy for total land holdings, which was not collected in the survey), productive assets (value of tractors, plows, wheel barrows, fishing nets, and traction animals), and consumer durables (including radios, refrigerators, cell phones, bicycles, and sewing machines). The vector of social and institutional assets includes community characteristics related to population,

Table 1. *Variable means for full sample and subsets*

Variable description	Full sample	GMAs	NonGMAs	Significance
Number of sample households	2,717	1,574	1,143	
Human capital				
Total household income (Kwacha)	4,235,762	3,591,253	5,123,301	*
Household size	5.28	5.08	5.57	***
Age of household head (in years)	42.46	41.00	44.48	***
Sex of household head (=1 if male)	0.74	0.73	0.76	**
Maximum education (in years)	6.78	6.42	7.27	***
Number of children (<15 years)	2.55	2.46	2.67	***
Number of female adults	1.10	1.08	1.12	
Number of male adults	1.03	1.00	1.07	**
Physical capital				
Cropped area (hectares)	0.92	0.93	0.92	
Value of consumer assets (Kwacha)	401,588	285,362	561,641	**
Value of productive assets (Kwacha)	618,036	256,729	1,115,584	***
Social and institutional assets				
Distance to nearest main road (km)	5.09	6.08	3.80	***
Population density (per km^2)	35.20	41.41	26.97	***
Infrastructure	3.62	3.64	3.59	
Locational characteristics				
Tourist lodge in SEA (=1)	0.07	0.10	0.02	***
GMA-1 (=1 if prime GMA)	0.17	0.30	n/a	
GMA-2 (=1 if secondary or specialized GMA)	0.20	0.35	n/a	

n/a, not applicable.
* 10% significance.
** 5% significance.
*** 1% significance.

remoteness, and access to markets. Distance in kilometers to the nearest all-weather road is expected to negatively influence income. Infrastructure is an index equal to a simple count of the number of schools, clinics, wells, and dip tanks in the community, and it is expected to have a positive sign. A population density variable is included to capture any remaining unobserved aspects of infrastructure.

Locational variables describe community characteristics in terms of location and availability of amenities that are hypothesized to have an effect on opportunities for employment. A dummy variable for the existence of a tourist lodge in the community is expected to have a positive sign because of opportunities for earning off-farm income.

Households in GMAs differ significantly from households in the control group across several variables. GMA households have lower average household incomes, lower levels of education, and fewer assets than households in other rural areas. GMA households are also more likely to be in more remote areas (as measured by distance to the nearest main road), relative to households in the control group.

We hypothesize that the stock and variety of wildlife has positive effects on household income and on the expected level of crop destruction. We, therefore, disaggregated the GMA variable into *GMA-1* for prime areas and *GMA-2* for secondary and specialized areas. The former takes the value of 1 if the household lives in a prime GMA (well stocked with a high variety of species; otherwise, the value is zero) and the latter takes the value of 1 if the household lives in a secondary or specialized area (lower stocks and variety than in prime areas; otherwise, the value is zero). The summarized empirical model is represented as follows:

$$\ln Y_i = \alpha + \beta X_i + \theta G_i + \varepsilon_i \quad (3)$$

where X_i is the combined vector of household and community characteristics from (2), and G_i is a vector of GMA dummy variables. Therefore, the null hypothesis that a GMA has no effect on household income is:

$$H_0: \ \theta = 0 \quad H_A: \ \theta \neq 0 \quad (4)$$

(b) *GMA effect on the sources of household income*

We extended the analysis of the impact of GMAs on household income to examine the avenues through which the GMA effect is generated. Participation in nonfarm livelihood activities has been found to be associated with relatively higher levels of welfare (Barrett et al., 2001; Reardon, 1997). Participation in the wage labor market or engaging in entrepreneurial activities (e.g., micro-enterprises) may help to diversify sources of income to manage risk or cope with the adverse effects of external shocks (such as drought or flooding). To that end, we estimated the effect of GMAs on the probability of participating in off-farm activities (including both wage employment and income from self-employment activities) and on the value of earnings generated from those activities. We also estimated the effect of GMAs on participation in crop agriculture and on the value of crop earnings.

Since fewer households reported wage earnings and self-employment earnings, the dependent variable takes a zero value for a nontrivial part of the sample. Such corner-solution models generate biased and inconsistent parameter estimates with OLS, in which the dependent variable takes a zero value for a nontrivial part of the population and the values greater than zero are continuous (Gujarati, 2003; Wooldridge, 2008). Tobit models are often used with corner-solution samples, but such models estimate the determinants of the probability of an outcome and the magnitude of their effects simultaneously. Estimation of a single set of parameters implies an assumption that coefficients on the probability and level are equal, which may not always be reasonable (for

example, see Lin & Schmidt, 1984). The technique for tobit models involves maximum likelihood (ML) estimation. The method defines a latent variable Y_i^* as:

$$Y_i^* = X_i\beta + \varepsilon_i \sim Normal(0, \sigma^2) \tag{5}$$

which satisfies the classical linear model assumptions. The relationship between the observed Y_i and the latent variable Y_i^* is expressed as follows:

$$Y_i = \begin{cases} Y_i^* & \text{if } Y_i^* > 0 \\ 0 & \text{if } Y_i^* < 0 \end{cases} \tag{6}$$

or alternatively, $Y_i = max\ (0, X_i\beta + \varepsilon_i)$.

The Cragg tobit alternative (Cragg, 1971) presents a variation of the tobit model that allows for separate estimation of the probability of participation and the value of that damage. Such two-stage models consist of both a probit and a continuous regression. Using the example of off-farm income, two-stage models can be used to first estimate the effects on household participation in off-farm activities (which may include factors such as transaction costs and gender barriers), and second to estimate the effects on the level of income from those activities (which may include age, education, and location) (Woldehanna et al., 2000).

Nonfarm employment may be observed when a household is willing and able to participate in nonfarm work or in the labor market. Let D be a household's decision to work outside its own farm. In an agricultural household model, an individual will participate in off-farm work when his reservation wage (w_{ri}), is less than the off-farm wage (w_{mi}), net of commuting and other transaction costs (Woldehanna et al., 2000). The participation decision (D_i) can be expressed as a latent variable as follows:

$$D_i^* = X_i'\gamma + \mu_i, \quad \text{where } \mu_i \sim Normal(0, \sigma^2) \tag{7}$$

$$D_i = \begin{cases} 1 & \text{if } D_i^* > 0 \text{ or } (w_{ri} < w_{mi}) \\ 0 & \text{if } D_i^* < 0 \text{ or } (w_{ri} \geqslant w_{mi}) \end{cases} \tag{8}$$

The relationship between the participation decision and the level of the outcome (income in this case) defined as a latent variable Y_i^* is specified as follows:

$$Y_i^* = X_i\beta + \varepsilon_i \quad \text{where } \varepsilon_i \sim Normal(0, \sigma^2) \tag{9}$$

The relationship between the latent variable Y_i^*, the observed variable Y_i, and the participation decision D_i can be expressed as follows:

$$Y_i = \begin{cases} 1 & \text{if } Y_i^* > 0 \text{ and } D_i = 1 \\ 0 & \text{if } D_i = 0\ (Y_i^* \leqslant 0) \end{cases} \tag{10}$$

This specification allows separate sets of factors to influence the decision to participate in nonfarm employment and the level of nonfarm earnings. X_i' and X_i are the vectors of explanatory variables that affect the two-stage processes. The error terms in both equations are assumed to be normally and independently distributed, which implies that any unobservable variables do not affect both stages. We modeled the probability and value of participation in nonfarm activities, testing the null hypothesis that living in GMAs has no effect on the probability of participating in nonfarm activities and reporting higher earnings from these activities than households living in secondary or specialized GMAs or in rural areas outside GMAs. We followed the same procedure to model the probability of participation in crop agriculture and the level of crop earnings.

We used the Cragg tobit alternative model to estimate the probability of households participating in off-farm activities and the determinants of off-farm household income. The independent variables selected for the analyses are the same as were used in the model for total household income as these are assumed to also influence the probability of participating in nonfarm employment and the value of nonfarm income. The Cragg model is specified as:

$$\text{Tier 1}: \ P(D_i = 1/X_i) = \gamma X_i + \mu_i \tag{11}$$

$$\text{Tier 2}: \ \ln Y_i = \alpha + \beta X_i + \varepsilon_i \tag{12}$$

where D_i is the participation decision variable (which takes the value 1 if the household decides to enter the nonfarm employment sector); $\ln Y_i$ is the logarithm of income from nonfarm employment; X_i is the vector of household and community characteristics, which are assumed to be the same as those specified in (2); γ is the vector of coefficients associated with X_i in the probability equation (Tier 1); μ_i is the error term in the probability equation; α is the intercept in the continuous equation (Tier 2); β is the vector of coefficients associated with X_i in the continuous equation; and ε_i is the error term. Note that X_i is assumed to be the same for both tiers. We used this model in two analyses related to off-farm income—first in an estimation of the effect of GMAs on the probability and value of income from wage employment, and then in an analysis of the probability and value of income from self-employment. We then followed the same approach to estimate the GMA effect on crop agriculture.

(c) *GMA effect on losses from crop damages*

Finally, we used a similar theoretical framework to model the effect of crop losses resulting from wildlife damage, but in this case, the "participation" variable is defined to represent the experience of crop damage, and the level of outcome variable represents the value of crop losses. We modeled the probability of crop losses and value of damages, testing the null hypothesis that living in prime GMAs has no effect on the probability of experiencing crop damage and reporting higher values of crop losses than households living in secondary or specialized GMAs or in rural areas outside GMAs.

Only 14% of respondents reported crop losses related to wildlife damages, which presents a similar corner-solution sample as the case of nonfarm income. Hence, we used the same Cragg tobit alternative model to estimate the effect of living in a GMA on the probability of crop damage and the value of losses. The empirical model is represented as follows:

$$\text{Tier 1}: \ P(CD_i = 1|X_i) = \varphi X_i + \mu_i \tag{13}$$

$$\text{Tier 2}: \ \ln Z = \alpha + \delta X_i + \varepsilon_i \tag{14}$$

where CD is the crop damage variable which takes the value 1 if the household reported crop loss, Z is the total value of crop losses, and all other variables are as defined in (2).

4. RESULTS

(a) *GMA effect on household income*

The results of the OLS regression are presented in Table 2. All coefficients have the *a priori* expected signs and for the most part are significant at 1%, 5%, or 10%. The age of the household head is negatively and significantly associated with household income. Male-headed households show a positive

Table 2. *Ordinary least squares regression of the effect of GMAs on household income*

Variable	Coefficient (standard error)	Significance
Intercept	13.101 (0.122)	***
Human capital		
Age of household head (in years)	−0.003 (0.002)	*
Sex of household head (=1 if male)	0.069 (0.060)	
Maximum education (in years)	0.043 (0.009)	***
Number of children (<15 years)	0.019 (0.015)	
Number of female adults (15–60 years)	0.113 (0.036)	***
Number of male adults (15–60 years)	0.070 (0.033)	**
Social and institutional assets		
Distance to nearest main road (km)	−0.005 (0.002)	***
Population density (per km^2)	0.001 (0.000)	***
Infrastructure	0.032 (0.011)	***
Physical capital		
Cropped area (hectares)	0.039 (0.022)	*
Log of consumer assets (Kw)	0.020 (0.002)	***
Log of productive assets (Kw)	0.010 (0.001)	***
Locational variables		
Tourist lodge in SEA (=1)	0.186 (0.107)	*
GMA-1 (=1 if prime GMA)	0.170 (0.069)	**
GMA-2 (=1 if secondary or specialized GMA)	0.022 (0.071)	

Dependent variable is logarithm of total household income.
$R^2 = 0.213$, $n = 2{,}264$.
* 10% significance.
** 5% significance.
*** 1% significance.

but insignificant association. The level of education (maximum education of any household member) is, as expected, significantly associated with higher levels of income. An additional year of education of the most highly-educated member increases total household income by 4.3%. The number of adults (men and women) is significant and positive, which is an expected result since income is aggregated at household level. Distance to the nearest all-weather road has a negative effect on income; an additional 10 km from a main road would decrease total household income by 5%. This result is consistent with the hypothesis that remoteness has a negative effect on household welfare by limiting opportunities for off-farm employment, raising the cost of transport, limiting access to markets, and increasing transaction costs (e.g., access to information, search costs).

Other factors positively and significantly affecting household income are the presence of a tourist lodge in the area, other aspects of infrastructure, and population density. Infrastructure and population density have been found to be positively associated with wage earnings (Haggblade, Hazell, & Brown, 1989; Reardon, 1997). Infrastructure levels may be associated with a reduction in transport costs, increased access to markets, greater provision of services (e.g., banks, extension services) and facilities (e.g., clinics, schools, wells) and greater access to employment opportunities. Population density is generally positively associated with income too; for any given level of infrastructure, population density generates greater opportunities for exchange.

Finally, results show that households living in a prime GMA (*GMA-1*) have 17% higher total incomes than comparable households residing in nonGMAs. For households living in secondary or specialized GMAs (*GMA-2*), the result is positive though not significant and relatively low in absolute terms. By classifying GMAs by stocking levels and diversity, we show that the GMA effect is dependent on the level and variety of wildlife population. This is an expected outcome since the potential benefits from living in a GMA are hypothesized to be directly linked to the tourism industry and the revenues obtained from wildlife hunting, which are dependent on wildlife resources. This result is also consistent with the aforementioned PSM analysis, which found that the average treatment effect of the GMA on household income is 0.147 or 14.7%. These results are also consistent with the findings of Bandyopadhyay and Tembo (2010), which used a treatment effects regression to conclude that households living in a GMA were positively associated with per capita consumption expenditures.

To explore how the GMA effect varies by type of household, we separated households into quintiles according to the value of consumer assets, created a series of dummy variables on this basis, and repeated the regression in Table 2, this time interacting the two GMA variables with the consumer asset dummies. Results indicate that the GMA effect is more likely to be attained by wealthier households (see Table 3).

The lowest 2 quintiles refer to the poorest 40% of the population, who according to the results are not significantly impacted by living in a GMA; the same result applies if the analysis is expanded to include the poorest 60% segment of the population. Only when the upper two quintiles are considered do the results become positive and significant, indicating that the gains derived from living in a GMA are likely to be attained by the nonpoor segment of the population. It is also worth noting that the impact is insignificant for all segments living in secondary or specialized GMAs. That wealthier households capture the positive impact of the GMA effect is not surprising. They are likely to be in a better position (in terms of access to financial, human, and political capital) to take advantage of the opportunities offered in the nonfarm sector as entrepreneurs and as wage employees (Haggblade, Hazell, & Reardon, 2007). Note that the dependent variable is current income, while current assets are a function of past income. This suggests that the same set of households has tended to benefit from the GMA through higher income over time, capitalizing previous income into higher current asset holdings. This may be further related to participation in community resource management, which has been found to be greater among households with greater wealth and levels of education. Bandyopadhyay and Tembo (2010) found that active members of CRBs may be paid allowances from ZAWA and may have greater access to credit from CRB funds. Conversely, weak participation levels among poorer households may limit the ability of households to capture some of the benefits of the GMA effect (Bwalya, 2003).

The results suggest that, *ceteris paribus*, there is a positive association between prime GMAs and household income. This association implies that the benefits derived from living in a GMA (mainly through tourism and CBNRM programs) outweigh the potential costs (mainly the opportunity cost of land

Table 3. *Comparison of GMA effect on household income by welfare level*

Consumer asset quintiles	*GMA-1*	*GMA-2*
Lower 2 quintiles	0.033	−0.059
Lower 3 quintiles	0.031	0.040
Upper 2 quintiles	0.046**	−0.008

** 5% significance level.

use and the probability of crop damage). The fact that the effect is only significant in prime GMAs indicates that the state of wildlife population is a key factor for the potential of tourism and CBNRM programs to generate employment and hunting revenues. The results also reveal that benefits are more likely to be attained by those groups in the upper quintiles of the welfare scale, suggesting an uneven distribution of the GMA effect among community members, a common finding in the literature of welfare and nonfarm rural income (Haggblade et al., 2007).

(b) *GMA effect on the sources of household income*

Of the 2,717 households in this analysis, only 9% ($n = 242$) reported wage earnings and 49% ($n = 1{,}322$) reported earnings from nonfarm businesses; 79 households (3%) reported having earnings from both sources. Table 4 shows that households employed in the wage labor market have higher average incomes (4.6 times) than households not receiving wage or self-employment earnings. They are also more likely to be younger and male-headed, better educated and larger in size. Households with income from wage employment are located nearer to main roads and in areas with greater population density and higher levels of infrastructure. Wage earning households are also more likely to live in areas where there is a tourist lodge and in GMAs as compared to the households not participating in wage employment or self-employment activities.

The results of the Cragg estimation of the probability of households participating in wage employment and the determinants of the value of wage income are presented in Table 5.

The first two columns (Tier 1 and Tier 2) present the results of the probability and continuous regressions, respectively. The coefficients for the Tier 1 equation are presented as the marginal effects in the third column (probit), and the coefficients for the Tier 2 equation are presented as average partial effects in the last two columns. The probit column presents the marginal effects of the independent variables on the probability of household participation in wage employment. The fourth column (CAPE) presents the conditional average partial effects on the expected value of wage earnings, which represent the effect of the independent variables on the value of wage income, only for the households who participate in wage employment ($E[Y|X_i,\ Y > 0]$). The fifth column (UAPE) represents the unconditional average partial effects of the expected value of wage earnings, which represent the impact of the independent variables on the value of wage income, without the condition of household participation in wage employment ($E[Y|X_i]$). The UAPEs are, therefore, dependent on both stages of the estimation, the probability and continuous regressions, and can be interpreted as the effect of each variable across all households, regardless of their participation in wage employment. From a policy perspective, the UAPEs represent the overall effects of the variables of interest, and are, therefore, useful as summary indicators. Significance testing for the CAPEs and UAPEs was done through bootstrapping in Stata with 500 iterations.

The results of the probability equation (probit) generally have the expected signs. Households with male heads of household and higher levels of education have a higher probability of participating in wage employment, which is consistent with previous studies of off-farm income (DeJanvry & Sadoulet, 2001; Reardon, 1997). Distance to the nearest all-weather road also has the expected sign; the probability of wage employment decreases by 1% for each 10 km from a main road. Population density and infrastructure are positively associated with the probability of wage employment. Households in communities where there is a tourist lodge are 6.6% more likely to report wage income than households in other areas.

The coefficient for the variable representing consumer durable assets has a positive and significant effect on access to wage labor. This can be an indication that, as highlighted by the empirical literature on nonfarm income, wealth and participation in wage employment are typically positively associated. Conversely, productive assets and cropped area decrease the probability of participating in wage employment, possibly reflecting the cumulative effect over time of decisions to focus on agriculture. The negative association may reflect the cumulative effect over time of decisions to participate in agricultural activities. This result may also suggest that households

Table 4. *Variable means for households reporting wage or self-employment income*

Variable description	With wage income	With self-employment income	No wage or self-employment income
Number of sample households	242	1,322	1,232
Human capital			
Total household income (Kwacha)	2,225,952	1,070,635	487,190
Age of household head (in years)	39.13	40.20	45.40
Sex of household head (=1 if male)	0.83	0.78	0.69
Maximum education (in years)	9.28	6.77	6.46
Number of children (<15 years)	2.63	2.69	2.42
Number of female adults	1.29	1.17	1.01
Number of male adults	1.20	1.08	0.96
Physical capital			
Cropped area (hectares)	0.74	0.84	1.03
Value of consumer assets (Kwacha)	1,026,838	464,244	278,084
Value of productive assets (Kwacha)	761,126	718,125	491,208
Social and institutional assets			
Distance to nearest main road (km)	2.91	5.70	4.77
Population density (per km^2)	89.70	39.38	26.42
Infrastructure	3.78	3.80	3.45
Tourist lodge in SEA	0.17	0.08	0.05
GMA-1	0.33	0.20	0.12
GMA-2	0.35	0.20	0.19

Table 5. *Two-stage analysis of the probability and value of income from wage employment*

Variable	Tier 1	Sig.	Tier 2	Sig.	Marginal effects					
					Probit	Sig.	CAPE	Sig.	UAPE	Sig.
Intercept	−3.084	***	15.533	***	n/a		n/a		n/a	
Age of household head	−0.004		−0.017		−0.000		−0.017		−0.009	
Sex of household head	0.259	**	−3.172	**	0.023	**	−3.109	*	0.234	
Maximum education (in years)	0.156	***	0.169		0.015	***	0.166		0.331	***
Number of children	−0.008		−0.306		−0.001		−0.300		−0.043	
Number of female adults	0.001		0.166		0.000		0.162		0.175	
Number of male adults	0.015		2.502	***	0.001		2.452	**	0.259	*
Cropped area (in hectares)	−0.046		−0.086		−0.005		−0.085		−0.101	
Log of consumer assets	0.017	***	0.021		0.002	***	0.021		0.037	***
Log of productive assets	−0.010	***	−0.002		−0.001	***	−0.002		0.035	***
Distance to nearest main road (km)	−0.008	**	−0.016		−0.001	**	−0.016		−0.018	
Population density (per km^2)	0.002	***	0.000		0.003	***	0.000		0.004	***
Infrastructure	0.028	*	−0.207		0.003	*	−0.203		0.038	
Tourist lodge in SEA (=1)	0.476	***	0.718		0.066	***	0.703		1.031	***
GMA-1	0.577	***	−0.090		0.078	***	−0.088		1.160	***
GMA-2	0.567	***	1.046		0.074	***	1.025		1.245	***
Log likelihood: −527.9										

n/a, not applicable.
* 1% significance level.
** 5% significance level.
*** 10% significance level.

without access to adequate farm land may search for off-farm opportunities to complement their incomes (Beyene, 2008). The negative or statistically insignificant relationship between land area and participation in wage employment is consistent with the findings of other studies (Tschirley & Benfica, 2001; Yúnez-Naude & Taylor, 2001).

The main variables of interest—the GMA effects—are positive and significant. Households living in prime GMAs are 7.8% more likely to be employed than households in other rural areas. The results are similar for households living in secondary or specialized GMAs, where they are 7.4% more likely to participate in wage employment. This result can be interpreted as being a consequence of greater employment opportunities in GMAs in the tourism sector and as village scouts; however, it could also suggest that households living in GMAs have lower reservation wages due to lower agricultural productivity and higher chances of crop destruction (push factors), and, therefore, are more prone to search for off-farm wage employment opportunities, though not necessarily outside the agricultural sector. The second stage provides useful insights for a more careful interpretation of results.

In the case of CAPEs, only the sex of the household head and the number of male adults are significant. The CAPE for the variable representing sex of household head indicates that wage earnings are three times lower for male-headed households that participate in wage employment, which contradicts the *a priori* expectation. However, the number of male adults is positively associated with level of wage earnings for households employed in wage labor.

The interpretation of UAPEs takes into account the entire population and the results of both tiers. For example, the UAPE indicates that the prime GMA effect on the level of wage income is positive and statistically significant (116%) despite a negative CAPE (−8.8%). The positive UAPE reflects the effect of the higher probability (7.8%) of a household earning wage income if located in a prime GMA, which outweighs the lower wage incomes in prime GMAs for those engaged in wage employment. In summary, the UAPE indicates that, in the absence of any *ex ante* knowledge of a household's employment status, households in prime GMAs can be expected to earn 116% more on average from wage labor than households outside GMAs. Note also that this effect holds even while controlling for the presence of a tourist lodge. The results are similar in secondary or specialized GMAs, due in part to this control for the presence of a lodge; households living in such GMAs earn an average of 124% more than households in other areas. One explanation for the negative CAPE for prime GMAs is the effect of in-migration on local wages. Prime GMAs may attract job seekers in search of job opportunities given by the tourism sector, which could eventually saturate the labor market and drive wages down.

We followed the same two-stage approach to estimate the effect of GMAs on the probability and value of income from self-employment activities. The results of this analysis are presented in Table 6.

In the probit column, the negative sign of the marginal effects for age suggests that households with older heads of household are less likely to participate in self-employment activities. However, the positive sign for the CAPE of age indicates that households with self-employment income tend to have higher returns to labor than younger households, possibly due to the effect of accumulated experience. The UAPE of age has a negative sign, indicating that the negative effect of the probability of being self-employed outweighs the positive effect on the level of income. Education has the opposite effect on self-employment compared to its impact on wage employment; households with more highly-educated members are less likely to be self-employed, perhaps because they have better opportunities for wage employment. Education also has a negative impact on the level of self-employment income, as indicated by the sign and significance of the UAPE and the CAPE. The numbers of children and adults are positively associated with both the probability of self-employment and the level of income (as indicated by the CAPE and UAPE); the extra labor resources may allow more time for the household head to attend to other business, and may also push the head into starting such businesses. Hectares of cropped area are negatively associated with self-employment, arguably for the same reasons suggested for wage employment. The coefficient of the value of consumer durable assets is positive, which implies that wealthier households are generally more likely to

Table 6. *Two-stage analysis of the probability and value of income from self employment*

Variable	Tier 1	Sig.	Tier 2	Sig.	Marginal effects					
					Probit	Sig.	CAPE	Sig.	UAPE	Sig.
Intercept	0.031		11.380	***	n/a		n/a		n/a	
Age of household head	−0.010	***	0.056	***	−0.004	***	0.052	***	−0.037	**
Sex of household head	0.137	*	0.843		0.055	*	0.787		1.267	*
Maximum education (in years)	−0.032	**	−0.183	*	−0.013	**	−0.171	*	−0.287	***
Number of children	0.029	*	0.089		0.012	*	0.083		0.231	*
Number of female adults	0.101	*	1.781	***	0.040	*	1.663	**	1.456	***
Number of male adults	0.066	*	1.241	***	0.026	*	1.158	**	0.984	***
Cropped area (in hectares)	−0.106	***	0.019		−0.042	***	0.018		−0.675	***
Log of consumer assets	0.006	*	0.016		0.002	*	0.015		0.043	*
Log of productive assets	0.000		−0.002		0.000		−0.002		0.035	
Distance to nearest main road (km)	0.003		−0.020		−0.001		−0.019	*	0.110	
Population density (per km^2)	0.000		0.007	**	0.000		0.007		0.005	
Infrastructure	0.045	***	−0.072		0.018	***	−.0067		0.261	***
Tourist lodge in SEA (=1)	0.057		−0.494		0.023		−0.461		0.146	
GMA-1	0.174	*	0.084		0.069	*	0.078		1.164	*
GMA-2	−0.132	*	0.330		−0.053	*	0.308		−0.707	
Log likelihood: −5144.9										

n/a, not applicable.
* 1% significance level.
** 5% significance level.
*** 10% significance level.

participate in off-farm activities. Higher levels of infrastructure are positively associated with the probability of self-employment.

Prime GMAs have a significant and positive impact on the probability of being self-employed, though both the magnitude and the significance are lower than for wage income. One of the benefits of living in GMAs is the generation of opportunities for micro-enterprises associated with the tourism sector; for example, higher population levels and economic activity creates opportunities for small business (e.g., selling mobile phone "talk time," owning restaurants, providing accommodation for local workers).

We followed the same approach to estimate the effect of GMAs on the probability and value of crop agriculture activities. The dependent variables for this model are the probability of participation in crop agriculture and the value of crop earnings. The results are presented in Table 7. The probit estimates show that the probability of participation in crop agriculture is negatively associated with education, reflecting the possibility that households with higher education have greater employment opportunities outside the farming sector. Distance to roads had a negative impact on the probability of farming, possibly reflecting the disincentive that distance to markets may have on the decision to engage in farming activities. Population density and the existence of a tourist lodge in the community are negatively associated with the probability of farming, both variables being linked to the existence of off-farm employment opportunities. Finally, the GMA effect on the probability of participation in crop agriculture is positive though insignificant for prime GMAs, and negative and significant in secondary or specialized GMAs.

Although significance levels for the UAPE and CAPE could not be calculated using the available bootstrapping program, it is notable that all the coefficients for both for prime (*GMA-1*) and secondary or specialized GMAs (*GMA-2*) are negative. This could be the result of a number of influences, including the effect of wildlife-related damages on the value of crops, the effect of encroachment from in-migration (which may put pressure on access to land), or the availability of off-farm employment (which may reduce the time dedicated to farming).

(c) *GMA effect on losses from crop damages*

The results of the two-stage analysis of the probability and value of crop losses are presented in Table 8. The model includes four variables not included in the OLS regression: the percentage of households that reported crop damage and the value of crop damage are included as dependent variables in this model. The number of village scouts was added as an additional explanatory variable to test for its effects on the probability and value of crop losses. Finally, the total value of crop harvest was included as a control variable to account for the effect that higher value crops (or higher yields per unit area) may have on the probability and value of crop loss.

Number of scouts may be endogenous to the crop damage regression, since higher stocks of wildlife (and thus higher crop damage) may lead to the hiring of more scouts using revenues from hunting through the CBNRM programs, especially in GMAs where wildlife is abundant and revenues are sufficient to support adequate staff. We tested for this possibility using a test for endogenous regressors (Hausman, 1978). Instruments for number of scouts were a dummy variable indicating whether the VAG had received funds from ZAWA, and three park system dummies. All four instruments were statistically significant above 0.01, and the Hausman test generated a Wald p-value of 0.33, which leads to failure to reject the null hypothesis of exogeneity. Therefore, we conclude that the number of scouts is not an endogenous variable in our two-stage model of crop losses.

Household size has a negative impact on the probability and value of crop loss, suggesting that additional labor may help contain wildlife and protect the fields. Distance to all-weather roads is positively associated with the probability of crop damage, suggesting that, as expected, more remote areas are likely to have greater wildlife populations. Cropped area and total value of harvest are control variables to account for the effect that larger areas under cultivation and higher value crops (or

Table 7. *Two-stage analysis of the probability and value of earnings from crop agriculture*

Variable	Tier 1	Sig.	Tier 2	Sig.	Marginal effects					
					Probit	Sig.	CAPE	Sig.	UAPE	Sig.
Intercept	0.753	***	20.101	***	n/a		n/a		n/a	
Age of household head	0.001		−0.025		0.0001		−0.02		−0.02	
Sex of household head	−0.028		−1.483	*	−0.001		−1.172		−1.15	
Maximum education (in years)	−0.030	**	0.041		−0.002	*	0.033		−0.07	
Number of children	0.033		0.434	*	0.002		0.343		0.421	
Number of female adults	−0.070		0.359		−0.004		0.284		0.022	
Number of male adults	0.015		0.126		0.001		0.099		0.138	
Cropped area (in hectares)	1.440	***	3.163	***	0.076	***	2.5		7.054	
Log of consumer assets	−0.001		0.079	*	−0.000		0.062		0.054	
Log of productive assets	0.007	**	0.105	***	0.0004	*	0.083		0.073	
Distance to nearest main road (km)	−0.005	*	0.005		−0.0002	*	0.004		−0.01	
Population density (per km^2)	−0.001	***	−0.024	***	−0.0001	***	−0.019		−0.02	
Infrastructure	0.009		−0.351	*	0.0005		−0.278		−0.22	
Tourist lodge in SEA (=1)	−0.357	*	0.974		−0.026	*	0.7		−0.49	
GMA-1	0.016		−0.382	***	0.001		−0.302		−0.22	
GMA-2	−0.328	***	−8.115	***	−0.021	***	−6.415		−6.88	
Log likelihood: −8517.6										

n/a, not applicable.
Note: The bootstrapping of the CAPE and UAPE could not be calculated using the available programming.
* 10% significance level.
** 5% significance level.
*** 1% significance level.

Table 8. *Two-stage analysis of the probability and value of crop losses from wildlife damage*

Variable	Tier 1	Sig.	Tier 2	Sig.	Marginal effects					
					Probit	Sig.	CAPE	Sig.	UAPE	Sig.
Intercept	−2.324	***	5.587		n/a		n/a		n/a	
Age of household head	−0.002		0.013		−0.000		0.002		−0.001	
Sex of household head	−0.041		0.249		−0.006		0.032		−0.046	
Household size (#)	−0.039	**	−0.020		−0.006	**	−0.003		−0.076	**
Distance to nearest road (km)	0.006	**	−0.014		0.001	**	−0.002		0.009	*
Cropped area (hectares)	0.068	**	−0.003	*	0.010	**	−0.051	*	0.077	
Consumption assets (Kw)	−0.002		−0.015		−0.000		−0.000		−0.005	
Production assets (Kw)	−0.004	*	−0.394		−0.001	*	−0.002		−0.010	**
Population density	0.000		−0.001		−0.000		−0.000		−0.000	
Infrastructure	−0.006		−0.014		−0.001		−0.002		−0.013	
Number of scouts (#)	0.025		0.047		0.004		0.006		0.053	*
Value of harvest	0.041	***	0.189	***	0.006	***	0.024	***	0.102	***
GMA-1	0.780	***	0.080		0.161	***	0.010		1.486	***
GMA-2	0.643	***	0.172		0.122	***	0.022		1.238	***

n/a, not applicable.
* 1% significance level.
** 5% significance level.
*** 10% significance level.

higher yields per unit area) will have in the probability and total value of crop loss. As expected, both are positively associated with the probability of crop damage, though interestingly, for those households that suffered crop damage, cropped area is negatively associated with the total value of crop loss (CAPE).

The number of scouts hired in the community has a significant and positive effect on the probability and the value of crop damage. This finding suggests that effective anti-poaching patrol may help to increase (or sustain) wildlife populations.

Finally, the GMA effect on the probability of crop loss is, as expected, positive and significant, more so in prime GMAs than in secondary or specialized GMAs. The results clearly confirm the hypothesis that households are more likely to be affected by crop loss in better stocked GMAs. As mentioned before, the human-animal conflict represents one of the biggest threats to the success of CBNRM programs.

5. DISCUSSION AND POLICY IMPLICATIONS

The main goals of this study were to estimate the effects of living in a GMA on household income and to examine the avenues through which the GMA effect is generated. These questions were evaluated using econometric techniques that aimed to isolate the variables of interest. The first analysis used OLS regression to explore the relationship between GMAs and total household income. The remaining analyses used Cragg two-stage models to estimate the GMA effect on the sources of household income and on losses from crop damage.

Results support the hypothesis that the level and variety of wildlife are positively associated with household income, as indicated by the sign and magnitude of the coefficients for the variables representing prime and secondary or specialized GMAs. The results from the first model suggest that prime GMAs increase average net household income by 17%, while

secondary and specialized GMAs have no significant effect. Only households in the upper two asset quintiles are found to benefit from living in GMAs, which suggests an uneven distribution of the positive GMA effect, a common finding in the literature on poverty reduction and rural nonfarm income. We conclude that this may be related in part to wealth effects as well as likelihood of participation in CRBs and VAGs.

In an examination of the avenues through which the positive GMA effect is generated, we find that households in prime, secondary, and specialized GMAs are more likely to be employed in the wage labor market, and these households earn higher levels of income from wage employment, even while controlling for the presence of a tourist lodge in the area. We conclude that households in GMAs have greater opportunities for employment through the tourism sector and as village scouts. Prime GMAs have a significant and positive impact on the probability of being self-employed, and households in these areas enjoy higher levels of income from entrepreneurial activities. From this result, we conclude that GMA policies and tourism development generate opportunities for the creation of micro and small enterprises linked with the tourism sector and its related businesses.

The positive GMA effect supports the hypothesis that CBNRM policies contribute to household welfare, and it suggests that frameworks to protect natural resources for tourism development may create opportunities for income generation for rural households, primarily through off-farm employment. These results are consistent with previous findings that suggest that participation in nonfarm livelihood activities is associated with relatively higher levels of welfare. The two-stage analytical approach considers the probability and value of off-farm income separately, which permits the independent examination of the determinants of the participation decision and the magnitude of the effect. This methodology and the results of the analyses allows for a better understanding of both the barriers and transaction costs of participating in off-farm activities as well as the determinants of sources and levels of household income in GMAs.

Despite the overall positive effect of GMAs on household income, the final analysis found that GMAs are positively associated with the probability and the value of crop loss from wildlife conflicts. The results support the hypothesis that households living in areas with greater wildlife populations suffer higher losses from crop destruction, and confirm the views expressed by community leaders and residents during interviews. The threat of crop losses from wildlife damages is further reinforced by the results of the analysis of the GMA effect on crop agriculture, which indicate a negative association between GMAs and both the probability of participation in crop agriculture and the level of crop earnings. Current policies make no allowance for compensation in the event of damage from human–wildlife conflicts. Although wildlife conservation policies and the designation of GMAs appears to have had positive ecological effects in terms of protecting the population and diversity of wildlife resources, and a positive net effect on household incomes, future increases in wildlife population may exacerbate conflicts and escalate economic damages, potentially threatening the sustainability of tourism development and eroding community support for environmental conservation.

The positive GMA effect on total household income is only found in prime GMAs, which suggests that the level and diversity of wildlife stocks are linked to the potential of these areas to generate benefits for the community. However, the uneven distribution of the benefits of living in a GMA demonstrates that in order to have any meaningful impact on rural poverty alleviation, tourism development would need to be pro-poor by design. These findings suggest a role for policies that enhance upstream linkages between tourism and small enterprises in rural areas, particularly in agriculture, in order to boost rural incomes and increase demand for locally-manufactured goods (Torres, 2003; Kirsten & Rogerson, 2002).

The issue of crop losses from wildlife conflicts threatens the success of the GMA policies and the CBNRM programs. Overall, the findings of this study show that households living in GMAs obtain higher incomes compared to those in other rural areas, despite these losses. However, with increasing wildlife populations, there may be a threshold beyond which crop losses could reverse the positive GMA effect, reducing the welfare of rural households. Wildlife conservation and tourism development may be sustainable only if human–wildlife conflicts are minimized or compensated. Successful GMA policies that increase wildlife populations to a point where they are incompatible with community livelihoods could eventually cause more harm than benefit. Further research could consider a model that tests different scenarios, for example, analyzing the outcome of the GMA effect in case a significantly larger number of farmers are affected by crop loss, or by increasing the average value of crop loss. It would be particularly interesting to test this in prime GMAs where the number of reported incidents and value of damages are greater.

The issue of crop damage also suggests policy implications for the role of village scouts and their capacity to protect wildlife while simultaneously defending farmers from crop damage. The findings of this study indicate that there is a positive relationship between the number of scouts hired in the community and the probability of crop loss in GMAs, which could indicate success in protecting wildlife (hence, the proliferation of incidents), but also that scouts are not able to contain wildlife and prevent them from destroying agricultural fields. A review of the scouts' mandate could help clarify the role they are given in terms of resource management and community development. A mandate that is solely focused on wildlife protection may overlook the importance of the role of GMA communities in resource management. Policies that protect wildlife and minimize conflict may more effectively advance the overall goals of wildlife conservation.

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